increases the current density of emitted electrons during operation. The method that represents one embodiment of the present invention for fabricating enhanced Spindt tips employs metal chemical-mechanical-planarization ("CMP") in place of oxide CMP used in currently available methods to allow planarization of the metal layers and more precise control of the positioning of the point of the Spindt tip relative to the field extraction anode.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates principles of design and operation of a silicon-based field emitter tip.

Figure 2A shows an initial substrate upon which one or more Spindt tips are fabricated in a cross-sectional view, and Figure 2B shows the initial substrate in a perspective view.

Figure 3A shows a cross-sectional view of the first step in enhanced field emitter tip fabrication, and Figure 3B illustrates the first step in a perspective view.

Figures 4A-B show a first-metal interconnect on the surface of the substrate following the photolithographic etch step.

Figures 5A-B show the nascent field emitter tip following application of the thin-film resistive heating layer.

Figures 6A-B show the nascent field emitter tip following etching of the thin-film resistive heating layer.

Figures 7A-B illustrate the SiO_2 dielectric layer deposited over the thin-film resistive heating layer and substrate in cross-section and perspective, respectively.

Figures 8A-B show the cylindrical slot produced by the etching step.

Figures 9A-B illustrate the nascent field emitter device following deposition of the Si_3N_4 layer above the SiO_2 layer in cross-section and perspective, respectively.

Figure 10A illustrates the nascent field emission device following deposition and etching of the Si_3N_4 layer in cross-section.

Figure 10B illustrates the nascent field emission device following deposition of the second metal layer.

Figure 11A illustrates deposition of the second SiO_2 layer.

Figure 11B illustrates the nascent field emission device following patterning and etching of the second SiO_2 layer.

Figure 12A shows the nascent field emission device following deposition of the second Si_3N_4 layer.

Figure 12B shows the nascent field emission device following patterning and etching of the second Si_3N_4 layer.

Figure 13A shows the nascent field emission device following deposition of the third metallic layer.

Figure 13B shows the nascent field emission device following patterning and etching of the third metallic layer, the second oxide layer, the second metallic layer, and the first oxide layer to produce a final central, cylindrical well.

Figure 14A shows the nascent field emitter tip following this lateral etch.

Figure 14B shows the final Spindt-tip field emitter tip.

Figure 15 illustrates application of a next SiO_2 layer above the third metallic layer via TEOS deposition.

Figure 16 shows a completed five-metal-layer field emission device produced by the above-described procedures.

Figure 17 illustrates a computer display device based on field emitter tip arrays.

Figure 18 illustrates an ultra-high density electromechanical memory based on a phase-change storage medium.

DETAILED DESCRIPTION OF THE INVENTION

Several embodiments of the present invention are described below with reference to Figures 2-16. In Figures 2-9 both a cross-sectional view and a perspective view are shown of a region of a layered substrate that includes a nascent Spindt tip during the fabrication process. In Figures 10-16, only cross-sectional views are shown. These figures are not meant to imply particular dimensions or shapes of Spindt tip devices fabricated according to the method of the present invention. Instead, these figures are